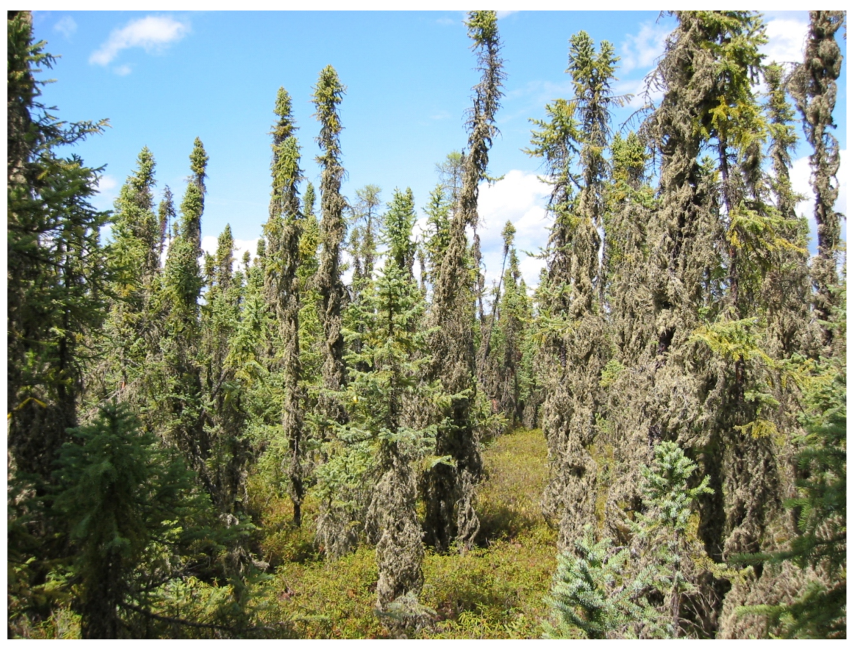
Understanding Boreal Peatland Response to Disturbance: A Collaborative Approach

Brian W. Benscoter[1,2], Dale H. Vitt[2], and R. Kelman Wieder[3]

[1]US Environmental Protection Agency Science To Achieve Results (STAR) Fellow

[2]Department of Plant Biology, Southern Illinois University, Carbondale, IL 62901 USA

[3]Department of Biology, Villanova University, Villanova, PA 19085 USA



ABSTRACT

Fire greatly impacts boreal peatland structure and function. The trajectory of post-fire vegetation recovery and concomitant changes in carbon (C) cycling are vital to accurately assessing peatland C balance. We have applied a multidisciplinary approach to assessing peatland recovery following fire that incorporates assessments of temporal vegetation compositional and functional change (production and decomposition), direct CO_2 flux measurements, and structure of the abiotic environment to construct a model of post-fire peatland recovery. Our results suggest burned peatlands may functionally recover in 3 years, but may require 75+ years to attain positive C balance compared to pre-fire conditions, drastically altering their role in the global C-cycle.

BACKGROUND

Boreal peatlands cover 3-4% of Earth's land surface but comprise about 1/3 of the terrestrial C pool (Gorham 1991). Therefore, understanding the C exchange dynamics of these systems is vital to characterizing the global C cycle and assessing global responses to climate change. Of particular importance is the response of peatlands to disturbance, particularly fire, as the extent and frequency of wildfire is projected to increase with global warming. Fire affects 1850 km^2 of peatland annually in western Canada (Turetsky *et al*. 2004), releasing 3.1 Tg C yr^{-1} to the atmosphere during combustion (Benscoter and Wieder 2003). Indirect post-fire C losses occur due to changes in vegetation composition and physical properties of the peatland (*i.e.*, increased surface temperature).

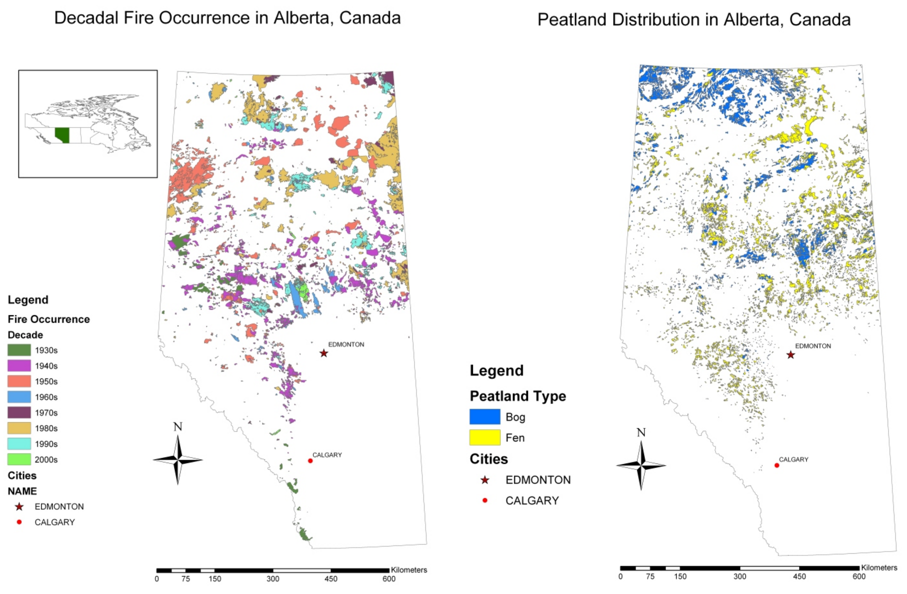


Figure 1. Decadal fire occurrence and peatland distribution in Alberta, Canada. Data provided by Alberta Sustainable Resource Development and Vitt et al. (1996), respectively.

METHODS

We have applied a multidisciplinary approach to assess bog peatland response and recovery from wildfire. Across a chronosequence of 13 historically burned bog peatlands, we are assessing:

1. Direct measurement of CO_2 gas exchange (not presented)
2. Spatial and temporal variability in vegetation composition
3. Peat accumulation dynamics (production and decomposition)

With this information, we will construct a post-fire recovery trajectory model for net peat accumulation, which can be used to more accurately assess bog C dynamics in relation to fire.

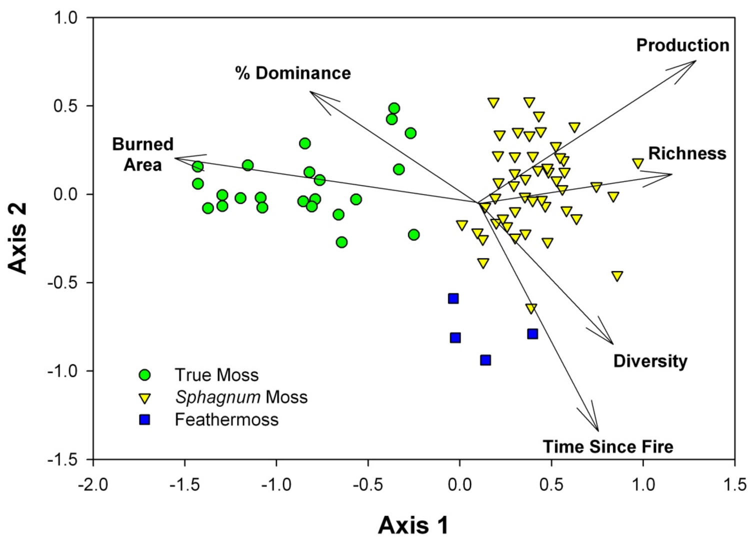


Figure 2. Two-dimensional NMDS ordination of sites along an historical fire chronosequence based on vegetation composition (stress = 0.161). Sites grouped based on hierarchical cluster analysis and labeled based on indicator species analysis.

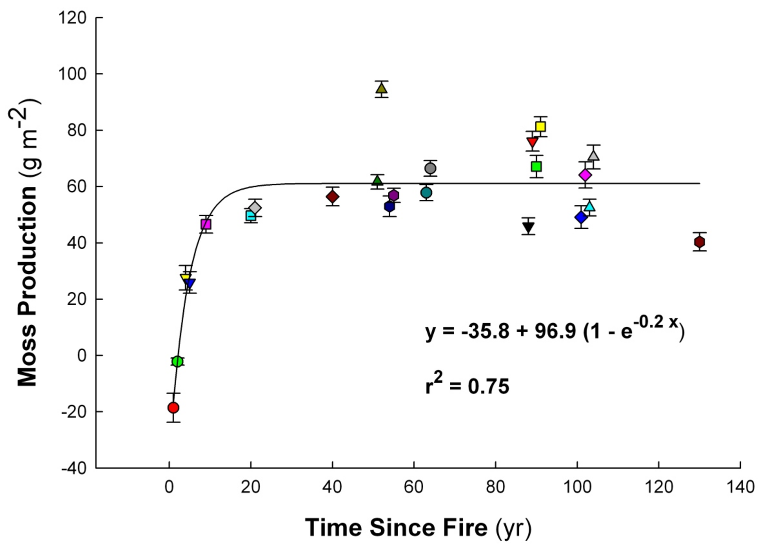


Figure 3. Mean ground layer peat accumulation ± SE (n=5) over time since fire. Paired symbol shapes indicate successive measurements in 2003 and 2004 at the same site.

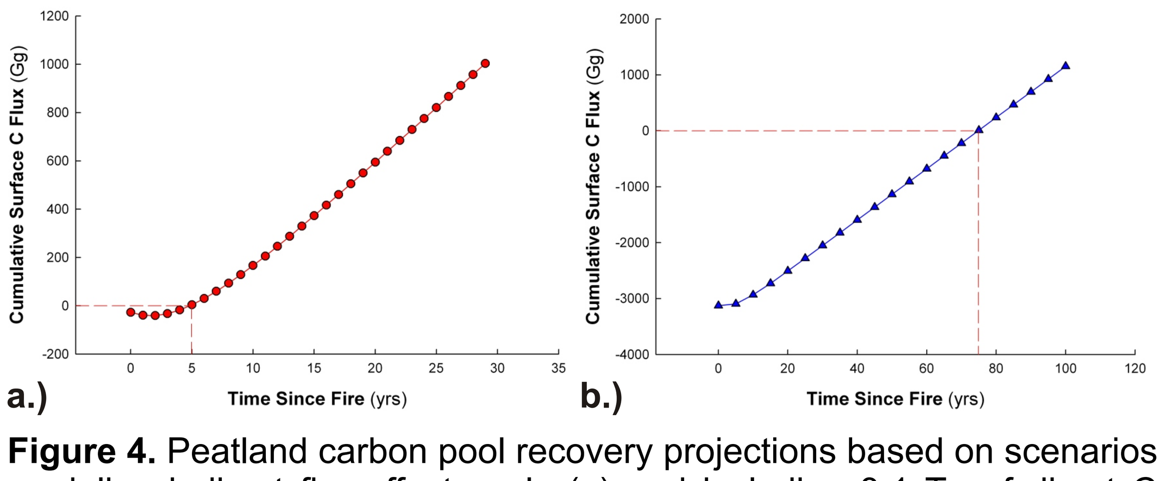


Figure 4. Peatland carbon pool recovery projections based on scenarios modeling indirect fire effects only (a) and including 3.1 Tg of direct C emissions during combustion (b). Dotted line indicates point at which C pool returns to pre-fire magnitude.

RESULTS AND DISCUSSION

Bogs grade through several communities following fire. True mosses (*Polytrichum*) dominate the early community, with shifts to *Sphagnum* and feathermoss (*Pleurozium*) dominance over time (Figure 2). Net peat accumulation rate showed an asymptotic temporal recovery trajectory post-fire, with positive functional net peat accumulation being achieved in approximately 3 years (Figure 3). However, it may take considerably more time for the C pool to rebound from the C balance deficit caused by three years of negative net production. By 20 yrs post-fire, the rate of peat accumulation begins to asymptotically level off, as peat accumulation rates are statistically similar between sites with 20 and 102 years of recovery.

IMPLICATIONS

Using the derived recovery equation, models of cumulative C pool change over time were generated using only surface processes (no bulk column decomposition) for one fire season cohort, analyzing scenarios involving only indirect fire effects (change in production; Figure 4a) and with the addition of direct emissions due to combustion (Figure 4b). Temporal returns to positive net peat accumulation (return to pre-fire C pool size) required approximately 5 yrs when only the indirect effects of fire were modeled and 75+ yrs when C emissions from combustion were included. Therefore, functional post-fire recovery of peatlands has a considerable time lag and is not indicative of a return to C sink status.

Future attempts to assess and model peatland C balance must take the direct and indirect affects of fire and functional temporal scale into account to make accurate assessments of peatland C status and terrestrial C cycling.

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FUTURE COLLABORATION

To foster future collaboration in peatland environmental science, our senior researchers have begun establishment of PEATNET (**P**eatland **E**cosystem **A**nalysis and **T**raining **NET**work). PEATNET is an international, interdisciplinary collaborative effort with the goals of fostering interactions among peatland scientists and educating the next generation of peatland ecosystem ecologists through establishment of Web-based resources and conducting workshops and retreats.